

CLAIM AMENDMENTS

Please cancel claims 1-23 (as filed) and insert new claims 24 – 83 as follows:

24. (new) An optical identification element for identifying an item, comprising:

a substrate having at least one diffraction grating disposed therein, said grating having a resultant refractive variation at a grating location;

said grating providing an output optical signal indicative of a code when illuminated by an incident light signal propagating in free space; and

the element being at least partially disposed on the item.

25. (new) The apparatus of claim 24 wherein said refractive index variation comprises at least one refractive index pitch superimposed at said grating location.

26. (new) The apparatus of claim 24 wherein said refractive index variation comprises a plurality of refractive index pitches superimposed at said grating location.

27. (new) The apparatus of claim 24 wherein said substrate is made of a material selected from the group: glass, silica, plastic, rubber, and polymer.

28. (new) The apparatus of claim 24 wherein said code comprises a plurality of digital bits.

29. (new) The apparatus of claim 24 wherein said code comprises at least a predetermined number of bits, said number being: 3, 5, 7, 9, 10, 12, 14, 16, 18, 20, 24, 28, 30, 40, 50, or 100.

30. (new) The apparatus of claim 24 wherein said code comprises a plurality of bits, each bit having a plurality of states.

31. (new) The apparatus of claim 24 wherein said code comprises a plurality of bits, each bit having a corresponding spatial location and each bit in said code having a value related to the intensity of said output optical signal at the spatial location of each bit.

32. (new) The apparatus of claim 31 wherein the value of said intensity is related to the magnitude of refractive index variation of a corresponding refractive index pitch in said grating.

33. (new) The apparatus of claim 24 wherein said code comprises a plurality of digital bits, each bit having a corresponding spatial location and each bit in said code having a binary value related to the intensity of said output optical signal at the spatial location of each bit.

34. (new) The apparatus of claim 33 wherein the value of said intensity is related to the presence or absence of a corresponding refractive index pitch in said grating.

35. (new) The apparatus of claim 24 wherein said incident light comprises a single wavelength.

36. (new) The apparatus of claim 24 wherein said incident light comprises a plurality of wavelengths or a single wavelength scanned over a predetermined wavelength range.

37. (new) The apparatus of claim 36 wherein said code comprises a plurality of bits, and each bit in said code having a value related to the intensity of said output optical signal at a wavelength corresponding to each bit.

38. (new) The apparatus of claim 37 wherein the value of said intensity is related to the magnitude of refractive index variation of a corresponding refractive index pitch in said grating.

39. (new) The apparatus of claim 36 wherein said code comprises a plurality of digital bits, and each bit in said code having a binary value related to the intensity of said output optical signal at the wavelength corresponding to each bit.

40. (new) The apparatus of claim 39 wherein the value of said intensity is related to the presence or absence of a corresponding refractive index pitch in said grating.

41. (new) The apparatus of claim 24 wherein said substrate has a length that is less than about 500 microns.

42. (new) The apparatus of claim 24 wherein said substrate has a diameter that is less than about 125 microns.

43. (new) The apparatus of claim 24 wherein said substrate has a reflective coating disposed thereon.

44. (new) The apparatus of claim 24 wherein said substrate has a coating disposed on at least a portion of said substrate, at least a portion of said coating being made of a material that allows sufficient amount of said incident light signal to pass through said material to allow detection of said code.

45. (new) The apparatus of claim 24 wherein said substrate has a coating material disposed on at least a portion of said substrate, said coating comprising a polymer.

46. (new) The apparatus of claim 24 wherein said substrate has a magnetic or electric charge polarization.

47. (new) The apparatus of claim 24 wherein said substrate has geometry having holes therein or having protruding sections therein.

48. (new) The apparatus of claim 24 wherein at least a portion of said substrate has an end cross sectional geometry selected from the group: circular, square, rectangular, elliptical, clam-shell, D-shaped, and polygon.

49. (new) The apparatus of claim 24 wherein at least a portion of said substrate has a side view geometry selected from the group: circular, square, rectangular, elliptical, clam-shell, D-shaped, and polygon.

50. (new) The apparatus of claim 24 wherein at least a portion of said substrate has a 3-D shape selected from the group: a cylinder, a sphere, a cube, and a pyramid.

51. (new) The apparatus of claim 24 wherein said substrate has a grating region where said grating is located and a non-grating region where said grating is not located; and wherein said substrate has a plurality of grating regions.

52. (new) The apparatus of claim 24 wherein said substrate has a grating region where said grating is located and a non-grating region where said grating is not located; and wherein said grating region has a refractive index that is greater than that of said non-grating region.

53. (new) The apparatus of claim 24 wherein said substrate has a grating region where said grating is located and a non-grating region where said grating is not located; and wherein said grating region has a refractive index that is not greater than that of said non-grating region.

54. (new) The apparatus of claim 24 wherein said incident light is incident on said substrate along a longitudinal grating axis of said grating.

55. (new) The apparatus of claim 24 wherein said incident light is incident on said substrate at an angle to a longitudinal grating axis of said grating.

56. (new) The apparatus of claim 24 wherein said incident light comprises laser light.

57. (new) The apparatus of claim 24 wherein said grating comprises a thin grating or a blazed grating.

58. (new) The apparatus of claim 24 wherein said substrate comprises a plurality of said gratings.

59. (new) The apparatus of claim 24 wherein said substrate comprises a plurality of said gratings each at different locations within said substrate.

60. (new) The apparatus of claim 24 wherein said substrate comprises a particle or bead.

61. (new) The apparatus of claim 24 wherein at least a portion of said substrate is disposed on an outer surface of the item.

62. (new) The apparatus of claim 24 wherein said substrate is disposed within said item and said item is made of a material that allows said code to be detected from output signal.

63. (new) The apparatus of claim 24, where the item is selected from the group, comprising: large or small objects, products, solids, powders, liquids, gases, plants, currency, ID cards, minerals, cells and/or animals.

64. (new) The apparatus of claim 24, where said code comprises a digital code indicative of information relating to: identity, type of item, lot number, manufacturer, serial number, date code, or code error checking.

65. (new) An item having a optical identification element disposed therein, comprising:

a substrate having at least one diffraction grating disposed therein, said grating having a resultant refractive index variation at a grating location;

said grating providing an output optical signal indicative of a code when illuminated by an incident light signal propagating in free space; and said code identifying the item.

66. (new) The apparatus of claim 65 wherein said refractive index variation comprises at least one refractive index pitch superimposed at said grating location.

67. (new) The apparatus of claim 65 wherein said refractive index variation comprises a plurality of refractive index pitches superimposed at said grating location.

68. (new) The apparatus of claim 65 wherein said substrate comprises a particle or bead.

69. (new) The apparatus of claim 65, where the item is selected from the group, comprising: large or small objects, products, solids, powders, liquids, gases, plants, currency, ID cards, minerals, cells and/or animals.

70. (new) The apparatus of claim 65, where said code comprises a digital code indicative of information relating to: identity, type of item, lot number, manufacturer, serial number, date code, or code error checking.

71. (new) A method of reading a code associated with an optical identification element that is disposed on an item, the element having a diffraction grating having a resultant refractive index variation at a grating location, comprising:

illuminating said element with incident light, said grating providing an output light signal indicative of the code; and

reading said output light signal and detecting said code therefrom.

72. (new) The method of claim 71 wherein said refractive index variation comprises at least one refractive index pitch superimposed at said grating location.

73. (new) The method of claim 71 wherein said refractive index variation comprises a plurality of refractive index pitches superimposed at said grating location.

74. (new) The method of claim 71 wherein said element comprises a particle or bead.

75. (new) The method of claim 71, where the item is selected from the group, comprising: large or small objects, products, solids, powders, liquids, gases, plants, currency, ID cards, minerals, cells and/or animals.

76. (new) The method of claim 71, where said code comprises a digital code indicative of information relating to: identity, type of item, lot number, manufacturer, serial number, date code, or code error checking.

77. (new) A method for labeling an item, comprising:
obtaining a substrate having at least one diffraction grating disposed therein, said grating having a resultant refractive variation at a grating location, said grating providing an output optical signal indicative of a code when illuminated by an incident light signal propagating in free space; and

said substrate being at least partially disposed on the item.

78. (new) The method of claim 77 wherein said refractive index variation comprises at least one refractive index pitch superimposed at said grating location.

79. The apparatus of claim 77 wherein said refractive index variation comprises a plurality of refractive index pitches superimposed at said grating location.

80. (new) The method of claim 77 wherein said substrate is disposed within said item.

81. (new) The method of claim 77 wherein said substrate comprises a particle or bead.

82. (new) The method of claim 77, where the item is selected from the group, comprising: large or small objects, products, solids, powders, liquids, gases, plants, currency, ID cards, minerals, cells and/or animals.

83. (new) The method of claim 77, where said code comprises a digital code indicative of information relating to: identity, type of item, lot number, manufacturer, serial number, date code, or code error checking.